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REVIEW ARTICLE

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A review of the adverse effects of laser hair removal

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Abstract Laser hair removal is ever increasing in popularity. Technology is fast advancing, and there are increasingly excessive commercial claims that laser hair removal in all skin types is free of side effects. The aim of this study is to review the evidence from published literature regarding the incidence of adverse effects after laser and light systems for hair removal. A review of the current published literature on the ill effects reported after laser/light-assisted depilation was conducted. Overall incidence of adverse effects after laser/light hair removal appears to be low, with very uncommon permanent sequelae. The two largest studies to date have shown that acute and transient side effects do occur. Higher incidence of pigmentary alterations is associated with the shorter wavelength lasers (up to 19%), particularly with darker skin types, compared with lower incidence using the neodymium–yttrium–aluminium–garnet laser (2–3%). Both studies did not show any long-term side effects or scarring. Laser/light hair removal, carried out by trained professionals, is a safe procedure with a very low incidence of permanent sequelae. The majority of adverse effects are transient and minor. They are more common in darker skin. Longer wavelength devices reduce the risk in darker skin.

Keywords Laser hair removal · Adverse effects · Hirsutism

Introduction

Popular demand from patients for laser hair removal has prompted a dramatic rise in the use of lasers and has resulted in rapid advancement in laser technology. Laser hair removal is generally considered a safe procedure, although there are adverse effects associated with it. These adverse reactions are primarily related to unwanted epidermal damage after partial absorption of the laser energy. Darker skin types and tanned skin result in greater absorption and greater risk of side effects. Epidermal cooling devices or the selection of longer wavelength devices for darker skin types can reduce the risk. The devices available and in use are the ruby, alexandrite, diode and neodymium–yttrium–aluminium–garnet (Nd:YAG) lasers and intense pulse light (IPL) sources.

Most laser devices target melanin in the hair follicle with millisecond-long pulse durations to produce some degree of selective photothermolysis of the hair follicles. The ruby laser uses 694-nm wavelength light, and it has the shortest penetration depth and the most selective absorption by melanin. The Nd:YAG laser, on the other end of the spectrum, emits at 1,064 nm in the infrared region, resulting in the deepest penetration depth but with least selective absorption. The alexandrite (755 nm) and diode (810 nm) lasers feature between these extremes. The IPL device operates on similar principles to lasers but emits polychromatic light. Using the photoepilation process, the device offers a broad spectrum of light (515 to 1,200 nm) to treat hirsutism.

For laser hair removal to be effective, short-term effects such as perifollicular erythema and oedema will result. These are not considered side effects but a necessary part of laser photothermolysis. Unwanted adverse effects of laser hair removal are recognised, the majority being the result of epidermal injury (Fig. 1). These include blistering, hypopigmentation, hyperpigmentation, and if extensive, even scarring.

Hyperpigmentation is usually reversible and results from the stimulation of melanin production from epidermal melanocytes similar to that seen in an ultraviolet-light-induced suntan. Avoidance of suntanning before and during treatment period may lessen the risk of pigmentary changes.

Hypopigmentation may be permanent, and it results from thermally induced destruction of melanocytes.

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Fig. 1 Post-inflammatory pigmentation and crusting after Nd:YAG laser treatment

Evidence from the larger studies

Previous studies have reported on the incidence of side effects. These have mainly involved relatively few treatment episodes and patients [1–3]. One of the largest studies to date is a multi-centre prospective study of 480 patients receiving 3,143 treatments in the UK, assessing the incidence of side effects in relation to skin type and laser/s used [4]. This study involved 11 Lasercare clinics. Lasercare in the UK is one of the major providers of both private and National Health Service funded laser treatments. Laser hair removal procedures were carried out by both doctors and trained nurses following protocols. Lasers used in the study included the long-pulsed ruby (Lambda, UK), long-pulsed alexandrite (LPIR, Cynosure, Chelmsford, MA used in one clinic; Gentlelase, Candela, Wayland, MA, used in three clinics; Apogee, Cynosure used in one clinic.) and the Lyra (Laserscope, San Jose, CA) long-pulsed Nd:YAG at 1,064 nm, pulse-width 50 ms and fluences up to 50 J cm^{-2}. Epidermal cooling devices such as gels, cold air, cryogen spray or cold contact plates were used as appropriate with the alexandrite and Nd:YAG lasers. A 3-month study period assessed all patients attending for laser hair removal who had had at least one previous laser treatment for side effects. The nature of side effects experienced, duration and laser responsible were recorded in addition to patient demographics (age, skin type, body area treated, number of treatments).

Of 3,143 treatments, 322 treatments used the ruby laser, 74 treatments used the alexandrite and 224 used the Nd:YAG.

For skin types I to II, the ruby laser was used in 191 patients producing blistering in 13 (6%). The alexandrite was used in 50 patients and produced blistering in one (2%). The Nd:YAG was used in 92 patients and blistering was seen in two (2%). Hypopigmentation was 1.6% in skin types I and II with the ruby laser, and hyperpigmentation was 1%.

For skin type III, incidence of blistering with the ruby laser was 4.5%, with the alexandrite 0% and with the Nd:YAG 8.8%. For hyperpigmentation, the incidence with the ruby was 2.8%, alexandrite 0% and the Nd:YAG 3%. Hypopigmentation occurred in only one patient after Nd:YAG laser therapy.

For patients with skin type IV to VI (109 patients in all), incidence of blistering with the ruby was 14.9% and 5% for the Nd:YAG. Incidence of hyperpigmentation for the ruby was 9.9% compared with 2.1% for the Nd:YAG. Overall incidence of side effects for this group was 9.4% with the Nd:YAG laser and 29.9% with the ruby laser.

In addition, the study also recorded atrophic scarring in one patient with skin type III after treatment with the ruby laser on the face. This scarring eventually almost cleared, and further treatment in the same patient later did not result in any further sequelae. One case of superficial thrombophlebitis also developed on the chin after treatment with the ruby and Nd:YAG lasers, persisting for 1 week.

This large prospective study has shown a very low incidence of persisting side effects. It also confirms that increased incidence of side effects is seen in darker skin types particularly when treated with the ruby laser. The recommendation from the study is that the ruby laser should not be used with darker skin types when alternatives such as the Nd:YAG laser can be used more safely. However, it did not address the association between clinical efficacy and the incidence of side effects.

Another large study is one by Nanni and Alster [5], who analysed the side effects from 900 consecutive laser hair removal treatments via a retrospective chart review. The major difference between this study and the study by Lanigan [4] is in the lasers used. Whilst the long-pulsed ruby and long-pulsed alexandrite lasers were similar, the Washington study used a Q-switched Nd:YAG (QS Nd:YAG) in combination with a patented carbon solution (Soft Light, Thermolase, La Jolla, CA) compared with the long-pulsed Nd:YAG laser used in the UK study. The study period was over 24 months. A total of 156 patients were studied, representing skin types I to V.

Results from this study showed that perifollicular oedema and post-treatment erythema occurred commonly, but this acute reaction cleared rapidly, usually within 1 to 4 h of treatment. Mild and transient pain was reported in greater than 87% of patients treated with any laser treatment system, but the need for topical or local anaesthesia was low, at less than 1% of patients. The incidence of folliculitis was 35% using the QS Nd:YAG with the patented carbon solution and less than 1% in the long-pulsed ruby and long-pulsed alexandrite. This higher incidence of folliculitis seen in the QS Nd:YAG treated group was presumed to be secondary to the pre-treatment wax depilation.

The incidence of hyperpigmentation with the ruby was 11%, alexandrite 19% and the QS Nd:YAG 3%. Hypopigmentation was seen in 18% with the ruby, 17% with the alexandrite and less than 1% with the QS Nd:YAG. Crusting was seen more commonly in the patients treated with the ruby and alexandrite lasers, with an incidence of 12% for both groups but less than 1% with the QS Nd:YAG. Conversely, the QS Nd:YAG-treated group resulted in a greater incidence of purpura (18%) compared

with 3% for both the ruby and alexandrite. Erosions were seen slightly more often in the ruby (2%) and alexandrite (2%) laser-treated patients and in less than 1% of the QS Nd:YAG group.

Complication rates also varied in accordance with the site treated. The lowest incidence was seen in sun-protected areas such as the axillae and inguinal regions, whilst the extremities were most commonly affected.

Overall, side effect rates were again highest in skin types III to V. The overall incidence of side effects for skin type V with the ruby laser was 37.8%, the alexandrite 37.7% and the QS Nd:YAG at 25.2%. Average duration of post-inflammatory hyperpigmentation lasted 2 months and hypopigmentation 3.5 months. Long-term side effects and scarring were not seen in any patient. Increased complication rates seen in the spring and summer were most likely due to increased sun exposure and tanning practices.

Data from smaller studies

Ruby laser

In other studies investigating the ruby laser, Campos et al. [3] reported that transient pigmentary changes were seen in 29% of patients, with five of six patients with skin type IV experiencing this. No permanent side effects or scarring were seen. In a Scandinavian study, Bjerring et al. [6] reviewed 133 patients and reported 14.3% experiencing hyperpigmentation and 9.8% experiencing hypopigmentation. The study by Sommer et al. [1] reported erythema and swelling in 61% and blistering in 14%. Minor crusting was seen in 33%. All resolved within 2 to 3 days. Mild hyperpigmentation (17%) resolved within 6 months and hypopigmentation was not seen. Permanent textural skin changes or scarring were not seen. Wimmershoff et al. [7], in a study of 74 patients, reported hyperpigmentation in 5%, hypopigmentation in 3% and atrophic scarring in 3%, with scarring only occurring in darker skin types. All the patients with hypopigmentation had skin types III to IV.

Alexandrite laser

With the alexandrite laser studies, Nanni and Alster [8] reported blistering and/or fine epidermal crusting seen in 10–15% of patients and significantly more so in darker skin types, but long-term complications and scarring were rare [9, 10]. Eremia et al. [11], in a study of 89 untanned patients of skin types I to IV undergoing 492 treatments, reported complications limited to transient post-inflammatory hyperpigmentation in 10% and post-inflammatory hypopigmentation in 2%, with one patient experiencing a burn with blistering. No scarring was noted. Another study from Saudi Arabia [2], on 150 patients with skin types IV to VI, showed complications in 2.7% of body locations, reporting axillary and bikini areas to be at risk. Two patients with skin type VI had adverse reactions with severe blistering seen in one. The authors also commented that residual pigmentary changes were seen in this skin type. Post-inflammatory pigmentary changes in the form of hyperpigmented rings progressing to wafer-thin crusting and hypopigmentation with eventual resolution to normal skin colour was reported in seven patients over 2.5 years in one centre using the alexandrite laser [12]. The use of cooling gels, cooling tip hand pieces and dynamic cooling devices can reduce the risk of epidermal injury through intermittent cooling of the skin [9, 13, 14]. Paradoxical hypertrichosis first reported with IPL therapy (vide infra) has now also been seen after alexandrite laser treatment [15].

Diode and Nd:YAG lasers

A number of studies have demonstrated the efficacy of longer wavelength devices, such as the diode and Nd:YAG lasers in hair removal [16–19], in patients with darker skin types [20, 21]. In a study comparing the long-pulsed diode and long-pulsed alexandrite lasers [17], patients rated intra- and post-operative pain with the alexandrite as mild to moderate compared to the diode, which rated moderate to severe pain especially at higher (40 Jcm^{-2}) fluences. Transient hyperpigmentation was seen in 10% with the diode laser. There was no evidence of scarring or atrophy.

In one study of the long-pulsed Nd:YAG laser for hair removal [18], complete depilation was reported after four to six sessions in 208 patients with no blistering or pigmentary changes. These results have not been matched in subsequent studies. Another study from Washington investigated 20 patients with skin types IV to VI [21]. Adverse effects were limited to mild to moderate pain at 90% of treatment sites, transient pigmentary alterations in 5% affecting exposed facial and leg areas only and vesiculation in 1.5%. Fibrosis or scarring was not seen. Histological tissue changes mirrored the clinical response rates with evidence of selective follicular injury without epidermal disruption. Once again, hair growth induced by diode laser therapy is now starting to be reported [22].

A recently reported and new side effect is reticulate erythema after diode laser hair removal [23]. Ten instances of patients with this side effect were reported. This has also been seen with long-pulsed Nd:YAG laser treatment (S. W. Lanigan, personal communication) and may reflect vascular damage after haemoglobin absorption by these deeper-penetrating wavelengths.

Intense pulse light systems

Studies have also confirmed the efficacy of IPL systems for hair removal [24, 25]. One of these studies [25] compared the long- and short-pulsed alexandrite laser with the IPL system and found no statistically significant difference in efficacy. Transient side effects were highest in the long-pulsed alexandrite group, compared with the least in the IPL system. Another study found mild and reversible side

effects with the IPL system in a minority of patients (hyperpigmentation in 9%, superficial crusting in 6%) using wavelengths of 615 to 695 nm [24]. Another study of 49 patients undergoing 390 treatment sessions of IPL photodepilation [26] reported transient erythema (n=30), late evanescent erythema (n=3), mild pain (n=43), moderate pain (n=6), crust formation (n=9), superficial burning (n=1), isolated vesicles (n=3), transient hyperpigmentation (n=8), transient hypopigmentation (n=1), persistent heat sensation locally (n=1) and minimal scar (n=1). This study also reported the paradoxical effect of the growth of new fine, dark hair in five patients involving untreated areas in close proximity to the treated areas, suggesting that IPL may induce activation of dormant hair follicles in untreated areas close to hirsute-treated areas. This unusual side effect of paradoxical hair growth has also been reported where IPL systems were used for other indications such as the treatment of port-wine stains and tattoos [27]. This side effect has now been reported with IPL, long-pulse alexandrite and diode lasers, and it is likely to be common to all current laser and light hair removal devices. Temporary or permanent leukotrichia can also develop after IPL hair removal. In a study of 821 patients, 29 patients treated developed leukotrichia with restoration of colour only occurring in nine patients within 2–6 months [28]. The remaining affected patients did not show any improvement or worsening of the condition in that time. A Singaporean study [29] compared single treatment response to the long-pulsed Nd:YAG laser and IPL therapy for hair removal in skin types IV to VI. Patients were treated on one half of the body with the long-pulsed Nd:YAG and the other half with the IPL system. Patients found the pain from the two systems different but both tolerable. Greater effect was seen with the Nd:YAG. Post-inflammatory pigmentation occurred in some patients with the IPL-treated sides but not the Nd:YAG-treated sides, with three patients experiencing blistering followed by post-inflammatory pigmentation. The author found that the long-pulsed Nd:YAG produces sufficient follicular injury with less epidermal damage in patients with darker skin types compared with the shorter wavelength laser and light systems.

Data from these studies may be influenced by the tendency to select lasers for patients according to their skin types. Small numbers of patients in some studies may also not reflect the true incidence of side effects. With studies using different lasers, protocols, treatment parameters, in addition to variations in operator treatment expertise, it is difficult to accurately and directly compare studies to obtain a true measure of incidence of side effects. However, recent larger studies have helped to give a clearer measure of incidence of side effects of laser and light hair removal.

Table 1 Principal adverse effects of laser hair removal

Acute short term effects (lasting hours to days)
Pain
Perifollicular erythema
Oedema blistering
Crusting folliculitis
Purpura
Thrombophlebitis
Cold urticaria
Post-inflammatory transient effects (lasting weeks to months)
Hyperpigmentation
Hypopigmentation
Leukotrichia
Reticulate erythema
Permanent adverse effects (rare)
Hyperpigmentation
Hypopigmentation
Atrophy
Scarring
Leukotrichia
Hypertrichosis (?permanent)

Table 2 More common adverse effects seen with specific lasers

Laser type	Common adverse effects seen
Ruby laser	Pain, blistering, crusting, erosions, purpura, thrombophlebitis, hyperpigmentation, hypopigmentation, scarring (higher incidence of pigmentary alterations and scarring with darker skin types)
Alexandrite laser	Pain, blistering crusting, purpura, postoperative extrusion of damaged hair shafts, hyperpigmentation, hypopigmentation, hypertrichosis
Diode laser	Moderate to severe pain, blistering, crusting, erosions, hyperpigmentation, hypopigmentation, hypertrichosis
Nd:YAG (QS/long-pulsed)	Purpura, folliculitis, pain, rarely hyperpigmentation and hypopigmentation (safer for darker skin types)
IPL hair removal systems	Moderate pain, crusting, erythema, hyperpigmentation, hypopigmentation, paradoxical hair growth in untreated areas in close proximity, temporary/permanent leukotrichia

Conclusions

From this review of published literature on laser and light hair removal, we can see that there are certainly associated adverse effects (Tables 1 and 2). However, these are generally fairly uncommon and short-lived, with very low incidence of permanent sequelae. We would advocate the use of longer wavelength lasers such as the Nd:YAG for patients with darker skin types to further reduce the risk of side effects.

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